made for the author by M. Renard of Brussels, and Mr. J. S. Grant Wilson of the Geological Survey of Scotland. The tuffs are partly basic, derived from the disruption of diabase lavas (48 per cent. of silica), partly acid, from the destruction of felsites (72 to 80 per cent. of silica). The microscopic structure of the tuffs was described, and slides and drawings were exhibited. The lavas are varieties of olivine-diabase. Their augite is remarkably abundant and fresh, and they contain scattered larger well-formed, as well as imperfect, crystals of olivine, generally in the form of hæmatitic pseudomorphs. No instance was observed of a siliceous lava having been erupted at the surface. The felsitic fragments in the tuffs must have been derived from the explosion of lavas that do not seem to have flowed out above ground. It was pointed out that this fact is exactly paralleled in the case of the volcanic group of the Lower Old Red Sandstone in the Pentland Hills.

In relation to the quartz-conglomerate, allusion was made to the constant recurrence of such conglomerates in the series of geological formations, and to the fact that they do not necessarily mark unconformability or the natural base of groups of sedimentary rocks.

2. *Geological Structure of the District.*—It was shown that the rocks have been folded into an isocline or inverted anticline, so that in one-half of the plication the dip of the strata is reversed.

The groups above mentioned are found in their proper order on both sides of the axis which runs through the volcanic group. The granite has risen irregularly through the eastern limb of the isocline. Small faults may occur here and there along the edge of the granite, but they do not in any way affect the general structure.

3. *The Foliation of the District.*—There has been extensively developed at St. David's a fine foliation of particular kinds of rock, more especially of certain fine tuffs and shales, which have passed into the condition of fine silky unctuous hydro-mica-schists or sericite-schists. A series of microscopic slices was described, which showed that the original clastic structure of the beds remains quite distinct, though an abundant development of fine flakes of a hydrous mica has taken place. This structure more particularly characterises the fine parts of the volcanic group, but it occurs also on various horizons in the groups above the conglomerate, thus linking the whole as one great continuous series of deposits. The author connected it with the plication of the district, and pointed out the great interest attaching to these fine schistose bands as revealing some of the incipient stages of the same process that had changed wide regions of sedimentary strata into crystalline schists.

4. *The Granite, Quartz-Porphyries, and accompanying Metamorphism.*—The petrographical characters of these eruptive rocks were described, and their perfect analogy to the familiar granites and elvans of other districts was pointed out. Specimens were shown illustrating the gradation from a true granite into spherulitic quartz-porphyry. The quartz-porphyries of St. David's (described by Mr. Davies, Dr. Hicks and others) exhibit spherulitic structure in an exceptionally perfect manner. Between the felso-spherulites the base is thoroughly micro-crystalline and not felsitic. The rocks belong to a group intermediate between granites and felsites. They occur in bosses, elvans, or dykes round the granite, cutting through all horizons of the volcanic group, and approaching, if they do not actually intersect, the quartz-conglomerate. The metamorphism associated with the granites and porphyries is best seen near the latter. It consists chiefly in the intense induration of certain bands of rock which have been converted into flinty aggregates (adinole). The alteration takes place usually along the bedding, which is nearly vertical; but veins of the same siliceous material ramify across the stratification of the shales. Examined microscopically, the adinole is found to have acquired a micro-crystalline structure, nests of quartz and orthoclase and porphyritic crystals of plagioclase having been developed, together with fine veins and filaments of crystalline quartz. These veins are here and there crowded with approximately parallel partitions of liquid inclusions showing freely moving bubbles. An analysis of a portion of the adinole, made for the author by M. Renard, shows the percentage of silica to be 78·62 with 5·80 of soda, indicating possibly the formation of albite. The author deferred generalising on the question of the metamorphism he described, but pointed out that a further study of the St. David's rocks could hardly fail to throw important light on the theory of metamorphism.

5. *The Diabase Dykes and Sheets.*—These are the latest rocks at St. David's, as they traverse all the others. Their macroscopic and microscopic characters were described, and allusion was made to the perfect fluxion-structure found in many of the dykes.

The paper closed with a summary of the geological history of St. David's. The earliest records are those of the volcanic group, which show the existence of volcanic vents in that region in an early part of the Lower Cambrian period. The volcanic accumulations were covered conformably by the conglomerate and succeeding Cambrian groups; but the same kind of tuffs continued to be ejected after the deposition of the conglomerate. At a later time this thick conformable succession of beds was plicated, and underwent a partial metamorphism, whereby some of the fine tuffs and shales were converted into sericite-schists. Subsequently a mass of granite rose through one side of the fold, accompanied by elvans of spherulitic quartz-porphyry, whereby a second, different, and feebler kind of metamorphism was induced. The last episode was that of the diabase dykes, which, crowded together in the granite, suggest that the granite boss stands on an old line of weakness and of escape for eruptive material from the interior.

As the conclusions drawn by the author from his study of the microscopic structure of the rocks of St. David's had been called in question at the reading of the first part of the paper, he took an opportunity before the reading of the second part to submit a series of typical specimens and microscopic slides to Professors Zirkel of Leipzig, Renard of Brussels, and Wichmann of Utrecht. These observers amply sustained his deductions. M. Renard came from Brussels to be present at the reading of the second part, and in the course of the discussion stated that Professors Zirkel, Wichmann, and himself had arrived at the following conclusions regarding the rocks of St. David's:—

1. The so-called "Dimetian" rock of St. David's is unquestionably a true granite. 2. The quartz-porphyries are just such rocks as might be expected to occur as apophyses of the granite, and the specimens from Bryn-y-Garn, Rock House, and St. David's left no doubt on their minds that such is really their origin. They cannot be confounded with rhyolitic lavas. 3. The conglomerate from the granite-contact shows secondary quartz between its pebbles. 4. The bands of fine tuff found intercalated with, and on various horizons above, the conglomerate, consist of true tuff, and cannot have been derived from the mere superficial waste of older volcanic rocks. 5. Fine foliation is well developed among the strata above the conglomerate as well as in the volcanic group below.

SOLAR PHYSICS[1]

THE lecturer introduced his subject by drawing attention to the circumstance that the idea of the sun being an exceedingly hot body was of very modern date, that both ancient and modern writers up to the early portion of the present century attributed to him a glorious and supernatural faculty of endowing us with light and heat of the degree necessary for our wellbeing, whilst even Sir William Herschel had attempted to find an explanation to account for his idea that the body of the sun might be at a low temperature, and inhabitable by beings similar to ourselves, which he did in surrounding the inhabitable surface by a non-conducting atmosphere—the penumbra—to separate it from the scorching influence of the exterior photosphere.

It was not till the views of Kant, the philosopher, had been developed by Laplace, the astronomer, in his famous "Mécanique Céleste," that the view gained ground that our central orb was a mass of matter in a state of incandescence, representing such an enormous aggregate as to continue radiation into space for an almost indefinite period of time.

The lecturer illustrated by means of a diagram the fact that of all the heat radiated away from the sun only 1/2,250,000,000 part could fall upon the surface of our earth, vegetation and force of every kind being attributable to this radiation, whilst all but this fractional proportion apparently went to waste.

Recent developments of scientific research had enabled us to know much more of the constitution of the sun and other heavenly bodies than had formerly been possible. Comte says in his "Positive Philosophy" (Martineau's translation of 1853) that "amongst the things impossible for us ever to know was that of telling what were the materials of which the sun was composed"; but within only seven years of that time Messrs. Bunsen and Kirchhoff published their famous research showing that, by connecting the dark Fraunhofer lines of the solar spectrum with the bright lines observed in the spectra of various metals, it was possible to prove the existence of those substances in the solar photosphere, thus laying the foundation of spectrum analysis, the greatest achievement of modern science. Dr. Huggins and others, applying this mode of research to other heavenly bodies, including the distant nebulæ, had extended our chemical knowledge of them in a measure truly marvellous.

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[1] Abstract of Lecture at the Royal Institution, by Sir William Siemens, F.R.S., April 27.

Solar observation had thus led to an analytical method by which chemistry had been revolutionised, and it would be, in the lecturer's opinion, through solar observation that we should attain to a much more perfect conception of the nature and effect of radiant energy, in its three forms of heat, light, and actinism, than we could as yet boast of. The imperfection of our knowledge in this respect was proved by the circumstance that whereas some astronomers and physicists, including Waterston, Secchi, and Ericsson, had, in following Sir Isaac Newton's hypothesis, attributed to the sun a temperature of several millions of degrees Centigrade, others, including Pouillet and Vicaire, in following Dulong and Petit, had fixed it below 1800° C.; between these two extremes other determinations based upon different assumptions had placed the solar temperature at between 60,000° and 20,000°.

The lecturer, having conceived a process by which solar energy may be thought self-sustaining, had felt much interested for some years in the question of solar temperature. If the temperature of the solar photosphere should exceed 3000° C., combustion of hydrogen would be prevented by the law of dissociation, as enunciated by Bunsen and Sainte-Claire Deville, and his speculative views regarding thermal maintenance must fall to the ground. To test the question he in the first place mounted a parabolic reflector on a heliostat, with a view of concentrating solar rays within its focus, which, barring comparatively small losses by absorption in the atmosphere and in the metallic substance of the reflector should reproduce approximately the solar temperature. By introducing a rod of carbon through a hole at the apex of the reflector until it reached the focus, its tip became vividly luminous, producing a light comparable to electric light. When a gas burner was arranged in such a way that the gas flame played across the focal area, combustion appeared to be retarded but was not arrested, showing that the utmost temperature attained in the focus did not exceed materially that producible in a Deville oxyhydrogen furnace or in the lecturer's regenerative gas furnace, in which the limit of dissociation is also reached.

Having thus far satisfied himself, his next step was to ascertain whether terrestrial sources of radiant energy were capable of imitating solar action in effecting the decomposition of carbonic acid and aqueous vapour in the leaf-cells of plants, which led him to undertake a series of researches on electro-horticulture extending over three years, a subject which he had brought before the Royal Society and the Royal Institution two years ago. By these researches he had proved that the electric arc possessed not only all the rays necessary to plant-life, but that a portion of its rays (the ultra-violet) exceeded in intensity the effective limit, and had to be absorbed by filtration through clear glass, which, as Prof. Stokes had shown, produced this effect without interference with the yellow and other luminous and intense heat-rays. He next endeavoured to estimate the solar temperature by instituting a comparison between the spectra due to different known luminous intensities. Starting with the researches of Prof. Tyndall on radiant energy, supplementing them by experiments of his own on electric arcs of great power, and calling to his aid Prof. Langley of the Alleghany Observatory to produce for him a complete spectrum of an Argand burner, he concluded that with the temperature of a radiant source the proportion of luminous rays increased in a certain ratio: whereas in an Argand oil-burner only 2½ per cent. of the rays emitted were luminous, and mostly red and yellow, a bright gas flame emitted 5 per cent., the carbon thread of an incandescent electric light between 5 and 6 per cent, a small electric arc 10 per cent., and in a powerful 5000-candle electric arc as much as 25 per cent. of the total radiation was of the luminous kind. Prof. Langley, in taking his photometer and bolometer up the Whitley Mountain, 18,000 feet high, had proved that of the solar energy not more than 25 per cent. was of the luminous kind, and that the loss of solar energy sustained between our atmosphere and the sun was chiefly of the ultra-violet kind, which rays, if they penetrated our atmosphere, would render vegetation impossible. It was thus shown that the temperature of the solar photosphere could not materially exceed that of a powerful electric arc or indeed of the furnaces previously alluded to, leading him to the conclusion already foreshadowed by Sainte-Claire Deville and accepted by Sir William Thomson, that the solar temperature could not exceed 3000° C. The energy emitted from a source much exceeding this limit would no longer be luminous, but consist mainly of ultra-violet rays, rendering the sun invisible, but scorching and destructive of all life.

Not satisfied with these inferential proofs, the lecturer had endeavoured to establish a definite ratio between temperature and radiation, which formed the subject of a very recent communication to the Royal Society. It consisted simply in heating a platinum or iridio-platinum wire, a metre long and suspended between binding screws, by means of an electric current, the energy of which was measured by two instruments, an electro-dynamometer giving the current in amperes, and a galvanometer of high resistance giving the electromotive force between the same points in volts. The product of the two readings gave the volt-amperes or watts of energy communicated to the wire, and dispersed from it by radiation and convection. A reference to the lecturer's paper on the Electrical Resistance Thermometer, which formed the Bakerian Lecture of the Royal Society in 1871, would show that the varying electromotive force in volts observed on the galvanometer was a true index of the temperature of the wire, while being heated by the passage of the current; a law of increase of radiation with temperature was thus established experimentally up to the melting-point of iridio-platinum, which when laid down in the form of a diagram gave very consistent results expressible by the simple formula—

$$\text{Radiation} = Mt^2 + \phi t,$$

M being a coefficient due to substance radiating.

Sir William Thomson had lately shown that the total radiating energy from a unit of surface of the carbon of the incandescent lamp amounted to 1/67 part of the energy emitted from the same area of the solar photosphere, and taking the temperature of the incandescent carbon at 1800° C. (the melting-point of platinum which can just be heated to the same point), it follows in applying Sir William Thomson's deductions to the lecturer's formula that the solar photosphere does not exceed 2700° C., or, adding for absorption of energy between us and the sun, about 2800° C.—a temperature already arrived at by different methods. The character of the curve was that of a parabola slightly tipped forward, and if the ratio given by that curve held good absolutely beyond the melting-point of platinum iridium, it would lead to the conclusion that at a point exceeding 3000° C. radiation would become as it were explosive in its character, rendering a rise of temperature beyond that limit difficult to conceive.

Clausius had proved that the temperature obtainable in a focus could never exceed that of the radiating surface, and Sainte-Claire Deville that the point of dissociation of compound vapours rises with the density of the vapour atmosphere. Supposing interstellar space to be filled with a highly attenuated compound vapour, it would clearly be possible to effect its dissociation at any point, where, by the concentration of solar rays, a focal temperature could be established, but it was argued that the higher temperature observable in a focal sphere was the result only of a greater abundance of those solar vibrations called rays within a limited area, the intensity of each vibration being the outcome of the source whence it emanated: thus, in the focal field of a large reflector, the end of a poker could be heated to the welding point, whereas in that of a small reflector the end of a very thin piece of wire only could be raised to the same temperature. If, however, a single molecule of vapour not associated or pressed upon by other molecules could be sent through the one focus or the other, dissociation in obedience to Deville's law must take place irrespective of the focal area; but inasmuch as the single solar ray represented the same potential of energy as numerous rays associated in a focus, it seemed reasonable that it should be as capable of dealing with the isolated molecule as a mere accumulation of the same within a limited space, and must therefore possess the same dissociating influence. Proceeding on these premises, the lecturer had procured tubes filled with highly attenuated vapours, and had observed that an exposure of the tubes to the direct solar rays or to the arc of a powerful electric light affected its partial or entire dissociation; the quantity of matter contained within such a tube was too slight to be amenable to direct chemical test, but the change operated by the light could be clearly demonstrated by passing an electric discharge through two similar tubes, one of which had and the other had not been exposed to the radiant energy from a source of high potential. If space could be thought to be filled with such vapour, of which there was much evidence in proof, solar rotation would necessarily have the effect of drawing such vapour towards its polar surfaces and emitting it equatorially by an action independent of solar gravity, and which might be likened to that of a blowing fan. When reaching the solar photosphere, this circulating dissociated vapour would, owing to its accumulated density, flash into flame, and could thus be made to account in great measure for the maintenance of solar radiation, whilst its continual dissociation in space would account for the continuance of solar radiation into space without producing any perceivable calorific effect.

Time did not permit him to enter more fully on these subjects, which formed part of a solar hypothesis which he had ventured lately to bring forward, his main object on this occasion having been to elucidate the point of cardinal importance to that hypothesis, that of the solar temperature.

The lecture was illustrated by several experiments, showing the methods by which the dependence of radiation upon temperature had been arrived at.

UNIVERSITY AND EDUCATIONAL INTELLIGENCE

CAMBRIDGE.—Mr. H. Marshall Ward, M.A., late Scholar of Christ's College, First Class in the Natural Sciences Tripos, 1879, Lecturer at Owens College, and Fellow of Victoria University, has been elected Fellow of Christ's College.

It is proposed to appoint a Curator of the new Archæological Museum at Cambridge at a stipend of 150*l* a year. Valuable contributions towards developing the Museum in the direction of ethnology have been promised.

In a discussion on the proposed immediate appointment of a Professor of Physiology, it was mentioned that enlarged class-rooms and a lecture-room, which did not exist, would be needed. A hope was expressed that the Professorship of Pathology would be filled up as soon as there was a reasonable prospect of sufficient appliances in the form of laboratory, &c., being provided for the Professor.

MR. W. N. STOCKER, M.A., Fellow of Brasenose, has been appointed Professor of Physics at the Royal Indian Engineering College, Cooper's Hill. Mr. Stocker took a first-class in mathematics and also in natural science, and has been for the last eight years Demonstrator in the Clarendon Laboratory.

SCIENTIFIC SERIALS

Journal of the Russian Chemical and Physical Society, vol. xv. fasc. 1.—Researches on the naphtha of Caucasus, by MM. Beilstein and Kurbatoff. The naphtha from Bakou consists mostly of hydrocarbons of the C_nH_{2n} series, identical with the products of hydrogenisation of the aromatic series C_nH_{2n-6}. That of the Tzarskiye Kolodtsy has a different composition; it contains but little of the hydrocarbons of the C_nH_{2n} series, but chiefly those of the C_nH_{2n+2} types, with a mixture of those of the aromatic series C_nH_{2n-6}. This analysis explains why the petroleum derived from the Bakou naphtha, although having a greater density together with the same volatility, burns brighter than the American, as also the higher qualities of the oils received from this naphtha. Its hydrocarbons being all liquid it contains but little paraffin, and the greasing oils may be cooled to lower temperatures, without liberating paraffin.—On the use of hyposulphite of ammonium, instead of the sulphide of ammonium, in qualitative analysis, by A. Orlovsky.—On the hydrogenisation of turpentine and cymol, by P. Orloff.—Additions to the theory of the action of chloride of ammonium.—On the evaporation of liquids, by B. Sreznewsky, being the conclusion of a treatise which has appeared in several preceding numbers of the *Journal*. The conclusions arrived at are: the velocity of evaporation is not constant; the velocity of evaporation of drops depends upon their height, and increases as the height diminishes; at a height of an average size it is proportioned to the periphery of the basis.—An aërial calorimeter (a project of), by N. Hesehus.—Elementary demonstration of the pendulum formulæ, by V. Wolkoff.

Vol. xv. fasc. 2.—On the transformation of the primary radical of propyl into a secondary, being a continuation of the researches undertaken by MM. Kékulé and Schröter, on the transformation of bromide into isopropyl under the influence of alluminium bromide.—On the heat of dissolution of mixtures of salts, and on the principle of maximum work, by P. Chrustchoff.—Analysis of the mineral waters of Slavinsk, in the Government of Lublin, by M. Kondakoff. They may be considered as one of the best iron mineral waters, as they contain the least mixture of other mineral substance; that is, 0·19 to 0·22 parts of carbonate of iron out of 3·18 to 3·38 parts of other salts, against 0·37 to 4·36, contained in the water of Spa, or 0·45 to 6·14, and 0·24 to 5·45 in those of Altwasser and Reinerz.—On the chloride of pyrosulphuryle, by D. Konovaloff.—Analysis of sulphur concretions in the fireproof clay from Bakhmut, by M. Kondakoff.—On the structure of nitric compounds of the fatty series, by M. Kissel.—On the permutations of bases in solutions of their neutral salts, by Prof. Menshutkin (analysed elsewhere).—On the specific heat of several products of distillation of naphtha, by E. Kuhlin.—On a secondary product obtained during the preparation of allyldimethyl carbinol, by W. Dieff; it distilled at 165° to 185°, and its structure may be represented as $C_9H_{18}O$.—On the critical temperature of isomeric and homologous series, by A. Nadejdine. The supposition formerly made by the author as to the critical temperature increasing in the same proportion as the temperature of boiling is confirmed by experiments with a sufficient degree of accuracy; it would result that the functions which express the dependency of the critical temperature upon the molecular structure are the same as those expressing the same dependency of the temperature of boiling, and differ only by their constants.—On comets and solar radiation, by M. Schwedoff.—Several conclusions from the theorem of Carnot, by M. Sreznewsky, being a confirmation of the formula of Kirchhoff ("Ueber einen Satz der mechanischen Wärmetheorie") for the expression of the absorption of heat during the formation of saturated solutions, and a verification of it for a certain number of salts.

SOCIETIES AND ACADEMIES

LONDON

Royal Society, March 8.—"Note on the Reversal of Hydrogen Lines; and on the Outburst of Hydrogen Lines when Water is dropped into the Arc." By Professors Liveing and Dewar.

The concentration of the radiation of hydrogen in a small number of spectral lines would lead us to expect that the absorption of light of the same refrangibility as those lines would, at the temperature of incandescence, be correspondingly strong, and that therefore the hydrogen lines would be easily reversed. The mass of hydrogen which can be raised to a temperature high enough to show the lines is, however, so small that, notwithstanding the great absorptive power of hydrogen for the rays which it emits, the reversal of the lines has not hitherto been noticed. In fact, the lines are very readily reversed, and the reversal may be easily observed.

When a short induction-spark is taken between electrodes of aluminium or magnesium in hydrogen at atmospheric pressure, a large Leyden jar being connected with the secondary wire of the coil, the hydrogen lines show no reversal; but if the pressure of the hydrogen be increased by half an atmosphere or even less,[1] the lines expand and a fine dark line may be seen in the middle of the F line. As the pressure is increased, this dark line becomes stronger, so that at two atmospheres it is very decided. As the F line expands with increase of pressure, the dark line expands too, and becomes a band. It is best seen when the pressure is between two and three atmospheres. When the pressure is further increased, the dark band becomes diffuse, and at five atmospheres cannot be distinctly traced. No definite reversal of the C line was observed under these circumstances. The dispersion used, however, was only that of one prism.

By using a higher dispersion the reversal of both the C and F lines may be observed at lower pressures. For this purpose a Plücker tube was used, filled with hydrogen and only exhausted until the spark would pass readily when a large jar was used.

The light of the narrow part of the tube is, under these cir-

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[1] The metallic gauge connected with the Cailletet pump used is not at all sensitive, so the pressures here mentioned are only approximate.